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## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):

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Title of Invention:

Optimal Scaling of RAKE Output Symbols  
for WCDMA

Attorney Docket No.:

47253-00064USPL

Box Provisional Patent Application  
Commissioner for Patents  
Washington, D.C. 20231

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- Transmitted herewith is a Provisional Patent Application under 37 C.F.R. § 1.53(c) as identified above.
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- Applicant(s) claim(s) small entity status under 37 CFR 1.9 and 1.27.
- The filing fee for a Provisional Patent Application under 37 C.F.R. § 1.16(k) in the amount of \$160 is herewith enclosed.
- TOTAL FEE REQUIRED** \$160

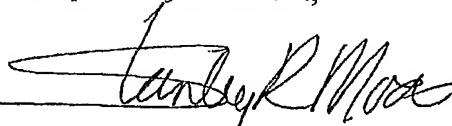
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Date: Feb 4, 2003

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Respectfully submitted,



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23932

PATENT TRADEMARK OFFICE

**PROVISIONAL APPLICATION COVER SHEET**

This is a request for filing a PROVISIONAL APPLICATION under 37 C.F.R. § 1.53(c)

Docket Number: 47253-00064USPL		Type a plus sign (+) inside this box → +	
INVENTOR(S)/APPLICANT(S)			
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TITLE OF THE INVENTION: Optimal Scaling of RAKE Output Symbols for WCDMA			
CORRESPONDENCE ADDRESS: Stanley R. Moore Jenkins & Gilchrist, P.C. 1445 Ross Avenue, Suite 3200 Dallas			
(STATE) TEXAS	(ZIP CODE) 75202-2799	(COUNTRY) USA	
ENCLOSED APPLICATION PARTS (check all that apply):			
<input checked="" type="checkbox"/> Specification	Number of Pages	8	<input type="checkbox"/> Small Entity Statement
<input checked="" type="checkbox"/> Drawings	Number of Figures	5	<input type="checkbox"/> Other: _____
<input checked="" type="checkbox"/> A check in the amount of <b>\$160</b> is enclosed to cover the provisional application filing fees. <input type="checkbox"/> The Commissioner is hereby authorized to charge or credit any over or under payments of filing fees to Deposit Account Number: <b>10-0447</b>			Filing Fees Due for Provisional Application:  <input checked="" type="checkbox"/> \$160.00 <input type="checkbox"/> \$80.00

Was the invention made by an agency of the United States Government or under a contract with an agency of the United States government?

- No.
- Yes, and the name of the U.S. Government agency and the government contract number(s) are:

Respectfully submitted,

NAME Stanley R. MooreDATE February 4, 2003

REGISTRATION NO.

(if appropriate)

**26,958**

- Additional inventors are being named on separately numbered sheets attached hereto.

**PROVISIONAL APPLICATION FILING ONLY**

Applicant(s) herein make claim to a new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof as substantially shown or described herein.

## Optimal scaling of RAKE output symbols for WCDMA

### 5 Technical Field of the Invention

The invention relates to a method of scaling the RAKE output symbols in a WCDMA receiver. The invention also relates to a corresponding receiver system.

### 10 Description of Related Art

In a WCDMA receiver system, see Figure 1, the radio signal is first down converted to base band by the radio interface, not shown in the figure. Then the analog signal is scaled by the automatic gain control (AGC), Block 101, before being quantized by the analog to digital (A/D) converter, Block 102.

15 The signal from the AGC is scaled to keep the average power of the sum of the  $I$  and  $Q$  parts as close as possible to a given reference value. The measured power could be taken before or after the A/D converter. Usually, some kind of control algorithm is involved in finding the optimal scale factor for the AGC. We assume that such an algorithm is given.

20

Once the received signal has been quantized it is despread in the RAKE. A radio signal could have travelled through different paths before arriving at the receiver, which causes the signal to be received at different time delays.

Given the time of arrival of each path, we despread the received quantized 25 signal in the RAKE, Block 103, for each path. In the RAKE, we multiply the quantized signal, sampled at chip rate, with its corresponding channelization code and scrambling code and sum over the length of the channelization code.

30 To minimize silicon area, as few bits as possible should be used to represent the output from the truncation and saturation block 104. In Figure 1, we assume that  $g_I$  and  $g_Q$  are represented with  $N_g$  bits. Here,  $z_I$  or  $z_Q$  is computed from  $g_I$  or  $g_Q$  by extracting the  $N_g$  least significant bits if this still equals  $g_I$  or

g<sub>Q</sub>. Otherwise, we have overflow and t<sub>I</sub> or t<sub>Q</sub> is set to the maximum or minimum representable value of t<sub>I</sub> or t<sub>Q</sub>, which depends on the sign of g<sub>I</sub> or g<sub>Q</sub>. By saturating the signals t<sub>I</sub> or t<sub>Q</sub>, we partly solve the problem of overflow. However, if only one of t<sub>I</sub> or t<sub>Q</sub> saturates, we will lose valuable phase information between g<sub>I</sub> or g<sub>Q</sub>, see Figure 2. If both t<sub>I</sub> and t<sub>Q</sub> saturates, we lose even more phase information, since only four phases are possible, see Figure 3. In both cases, we lose valuable soft information, which results in a deteriorated performance. In Block 105 the radio channel estimates are calculated and their conjugates are multiplied with the despread data symbols. The products are then summed over the number of paths. Finally, in Block 106 the bit stream is decoded.

The problem with the current state-of-the-art solution is that we lose valuable soft information if we want the RAKE output to be represented with a small number of bits. The result is a deteriorated performance.

#### Summary

In the invention, we propose a method to adaptively select the reference power value for the AGC or to scale g<sub>I</sub> and g<sub>Q</sub> with a reference scale factor before truncation and saturation in Block 204. The reference power level and the reference scale factor depend on the strength of the signal output from the RAKE. In Figure 4, we show an overview of the proposed system. Here Block 207 adjusts either the reference value in the AGC or the truncation and saturation done in Block 204.

With the proposed solution, we adjust the average size of the values output from the RAKE to obtain optimal performance.

#### Brief Description of the Drawings

The invention will now be described more fully below with reference to the drawings, in which

Figure 1 shows an overview of the receiver,

Figure 2 shows in a dotted box the maximum values of  $t_1$  or  $t_Q$ . In the figure the coordinate  $(g_1, g_Q)$  fall outside the box and will thus be truncated. The result of the truncation and saturation is shown as the coordinate  $(t_1, t_Q)$ . It is  
5 immediately seen that the truncation and saturation introduces a phase error,

Figure 3 shows in a dotted box the maximum values of  $t_1$  or  $t_Q$ . In the figure both  $g_1$  and  $g_Q$  fall outside the box and will thus be truncated. The result of the truncation and saturation is shown as the coordinate  $(t_1, t_Q)$ , which will be located at one of the corners of the box. It is immediately seen that the truncation and saturation introduces a phase error,  
10

- Figure 4 shows the proposed modified receiver structure, and  
15 Figure 5 shows a flow diagram of Block 207.

#### Detailed Description of Embodiments

Let  $|x|$  mean the absolute value of  $x$ . Let  $x$  be a number represented by an integer number of bits  $N_x$ . Define  $M_x$  and  $m_x$  to be the maximum and minimum  
20 achievable number using the bit representation of  $x$ . Let  $y$  be represented with  $N_y$  integer bits. Define the truncation of  $x$  using saturation as

$$y = sat(x) = \begin{cases} M_y, & x \geq M_y, \\ x, & m_y < x < M_y, \\ m_y, & x \leq m_y. \end{cases}$$

Let the integer part of the number  $x$  be represented as  $\text{floor}(x)$ .

25 Description of Block 207.

In Figure 4, we present the proposed solution. A flow chart of Block 207 is shown in Figure 5. Below, we go through in detail the boxes in Figure 5.

Block 301: Sample the  $I_i^{(CH)}$  and  $I_Q^{(CH)}$  according to a predetermined pattern for physical channel  $CH$ . A given number of physical channels can be studied in parallel. We are interested in if either the  $I$  or  $Q$  part has saturated. We therefore compute the measurement quantity

$$5 \quad \Omega^{(CH)} = \max(|I_i^{(CH)}|, |I_Q^{(CH)}|)$$

for each physical channel.

Block 302: Compute the expectation value of  $\Omega^{(CH)}$ . This can, for example, be done by filtering

$$10 \quad \Omega_{n+1}^{(CH)} = (1 - \alpha)\Omega_n^{(CH)} + \alpha\Omega^{(CH)}$$

Here, the time constant for  $\alpha$ , that is, the time it takes to compute the corresponding moving average, should be much larger than the time constant for the AGC loop. Furthermore, the time constant for  $\alpha$  should be large enough to filter over a number of fading peaks and dips.

15 Block 303: This block is the core of the invention. We present four different methods for computing the reference value,

Algorithm I (Adjusts the reference value for Block 201): Let  $\Omega_{ref}^{(CH)}$  be the reference value for  $\Omega_n^{(CH)}$ . Compute the new reference power value  $P_{ref}^{(CH)}$  for the AGC using a PI controller, that is, calculate

$$\epsilon_n^{(CH)} = \Omega_{ref}^{(CH)} - \Omega_n^{(CH)},$$

$$I_{n+1}^{(CH)} = I_n^{(CH)} + \frac{1}{T_i} \epsilon_n^{(CH)}$$

25 Here  $I_n^{(CH)}$  is stored from the last activation of the block and  $T_i$  is an integration constant. Take the new reference power for the AGC for channel  $CH$  as

$$P_{ref}^{(CH)} = K(e_n^{(CH)} + I_n^{(CH)})$$

for some constant  $K$ .

Usually, we have only one AGC and we set the final reference value as

$$5 \quad P_{ref} = \min_{CH}(P_{ref}^{(CH)}).$$

Algorithm II (Adjusts the reference value for Block 204): Let  $\Omega_{ref}^{(CH)}$  be the reference value for  $\Omega_n^{(CH)}$ . Compute the new reference scale value for Block 204,  $S_{ref}^{(CH)}$ , using a PI controller, that is, calculate

$$10 \quad e_n^{(CH)} = \Omega_{ref}^{(CH)} - \Omega_n^{(CH)},$$

$$I_{n+1}^{(CH)} = I_n^{(CH)} + \frac{1}{T_i} e_n^{(CH)}$$

Here  $I_n^{(CH)}$  is stored from the last activation of the block and  $T_i$  is an integration constant. Take the new reference scale value for Block 204 for channel  $CH$  as

$$15 \quad S_{ref}^{(CH)} = K(e_n^{(CH)} + I_n^{(CH)})$$

for some constant  $K$ .

The truncation and saturation in Block 204 is then done as follows,

$$20 \quad t_I^{(CH)} = \text{sat}(\text{floor}(g_I^{(CH)} \cdot S_{ref}^{(CH)})),$$

$$t_Q^{(CH)} = \text{sat}(\text{floor}(g_Q^{(CH)} \cdot S_{ref}^{(CH)})).$$

In algorithm I and II more general controllers can be used, but for ease of presentation we chose the simple PI controller.

**Algorithm III (Adjusts the reference value for Block 201):** The following algorithm is a simplified version of algorithm I. We assume that we have two reference power levels,  $P_1$  and  $P_2$ . Do the following

```

5      if  $\Omega_n^{(CH)} > M_{t_1} (1 - \gamma_1)$ 
           $P_{ref}^{(CH)} = P_1$ 
      elseif  $\Omega_n^{(CH)} < M_{t_2} (1 - \gamma_2)$ 
           $P_{ref}^{(CH)} = P_2$ 
      end

```

10 Here,  $M_1$  denotes the maximum value represented by  $t_1$ , which is the same for  $t_0$ . This algorithm toggles between two states. Here,  $\gamma_1 < \gamma_2$  and  $P_1 < P_2$ . Having  $\gamma_1 < \gamma_2$  introduces a viscosity to the system, which prevents us from toggling between the two reference values  $P_1$  and  $P_2$  from one activation of the block to the other.

15 Algorithm IV (Adjusts the reference value for Block 204): The following algorithm is a simplified version of algorithm II, similar in style to algorithm II. We assume that we have two reference scale levels,  $S_1$  and  $S_2$ . Do the following

```

20      if  $\Omega_n^{(CH)} > M_{t_1} (1 - \gamma_1)$ 
           $S_{ref}^{(CH)} = S_1$ 
        elseif  $\Omega_n^{(CH)} < M_{t_2} (1 - \gamma_2)$ 
           $S_{ref}^{(CH)} = S_2$ 
      end
    
```

Here,  $M_{t_j}$  denotes the maximum value represented by  $t_j$ , which is the same for  $t_Q$ . This algorithm toggles between two states. Here,  $\gamma_1 < \gamma_2$  and  $P_1 < P_2$ . Having  $\gamma_1 < \gamma_2$  introduces a viscosity to the system, which prevents us from toggling between the two reference values  $P_1$  and  $P_2$  from one activation of  
5 the block to the other.

The truncation and saturation in Block 204 is then done as follows,

$$t_I^{(CH)} = \text{sat}(\text{floor}(g_I^{(CH)} \cdot S_{ref}^{(CH)})),$$

$$t_Q^{(CH)} = \text{sat}(\text{floor}(g_Q^{(CH)} \cdot S_{ref}^{(CH)})).$$

- 10 It is straight forward to generalize algorithm III and IV to include more power reference value levels.

- 15 Although a preferred embodiment of the present invention has been described and shown, the invention is not restricted to it, but may also be embodied in other ways within the scope of the subject-matter defined in the following claims.

## Optimal scaling of RAKE output symbols for WCDMA

### ABSTRACT

In a WCDMA receiver, we propose a method to adaptively select the reference power value for the AGC or to scale the despread data symbols provided from the RAKE unit with a reference scale factor before truncation and saturation. The reference power level and the reference scale factor depend on the strength of the signal output from the RAKE. With the proposed solution, we adjust the average size of the values output from the RAKE to obtain optimal performance.

Fig. 4 should be published.

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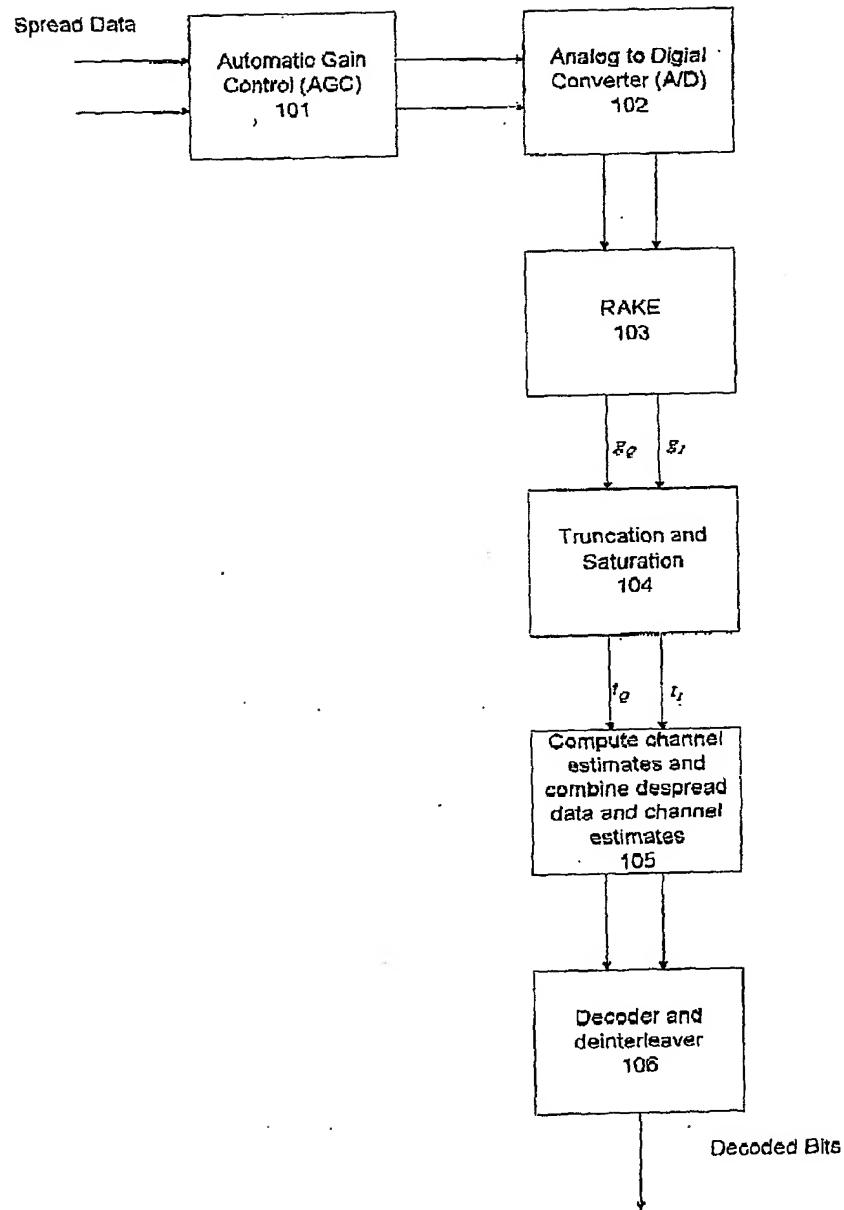


Fig. 1

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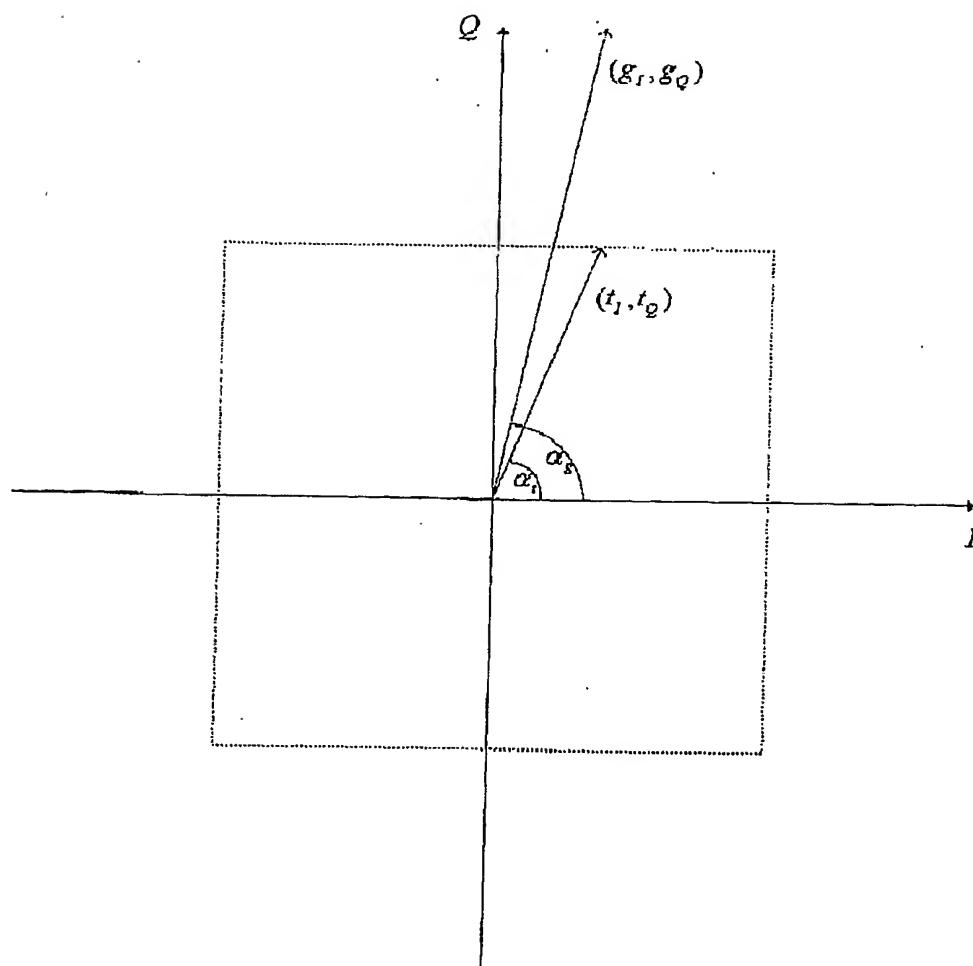


Fig. 2

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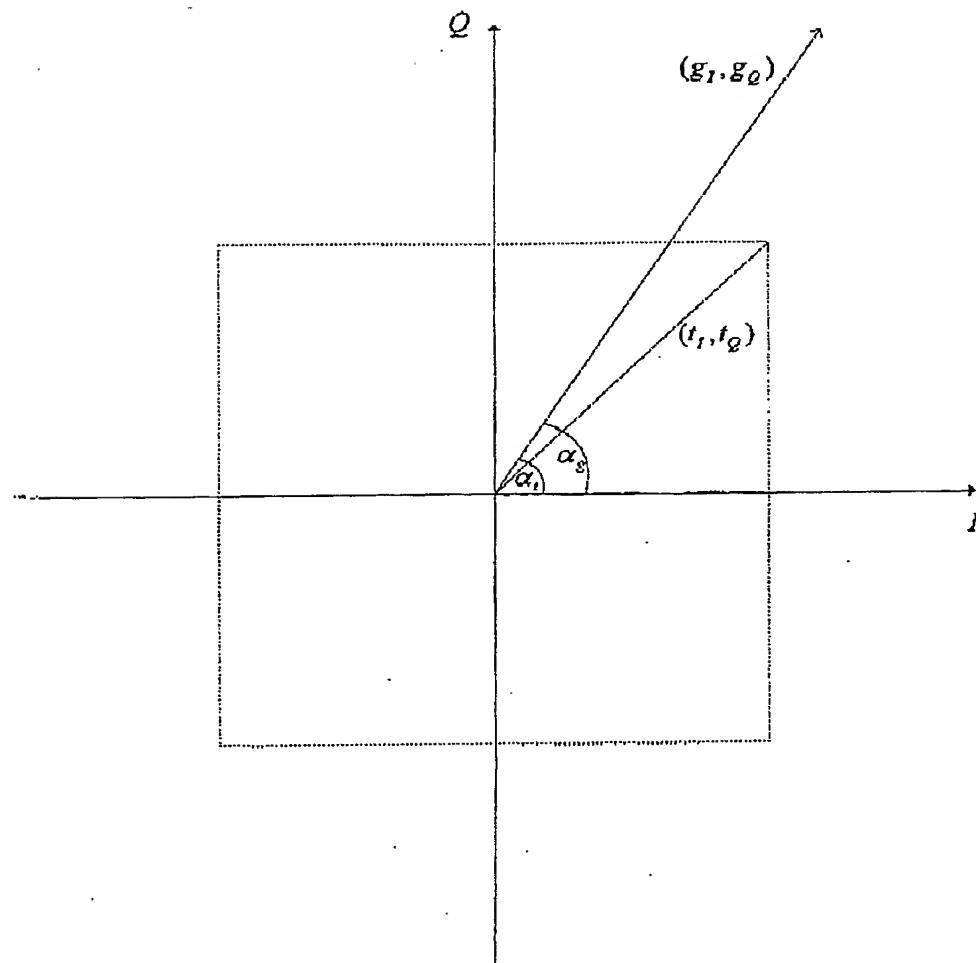


Fig. 3

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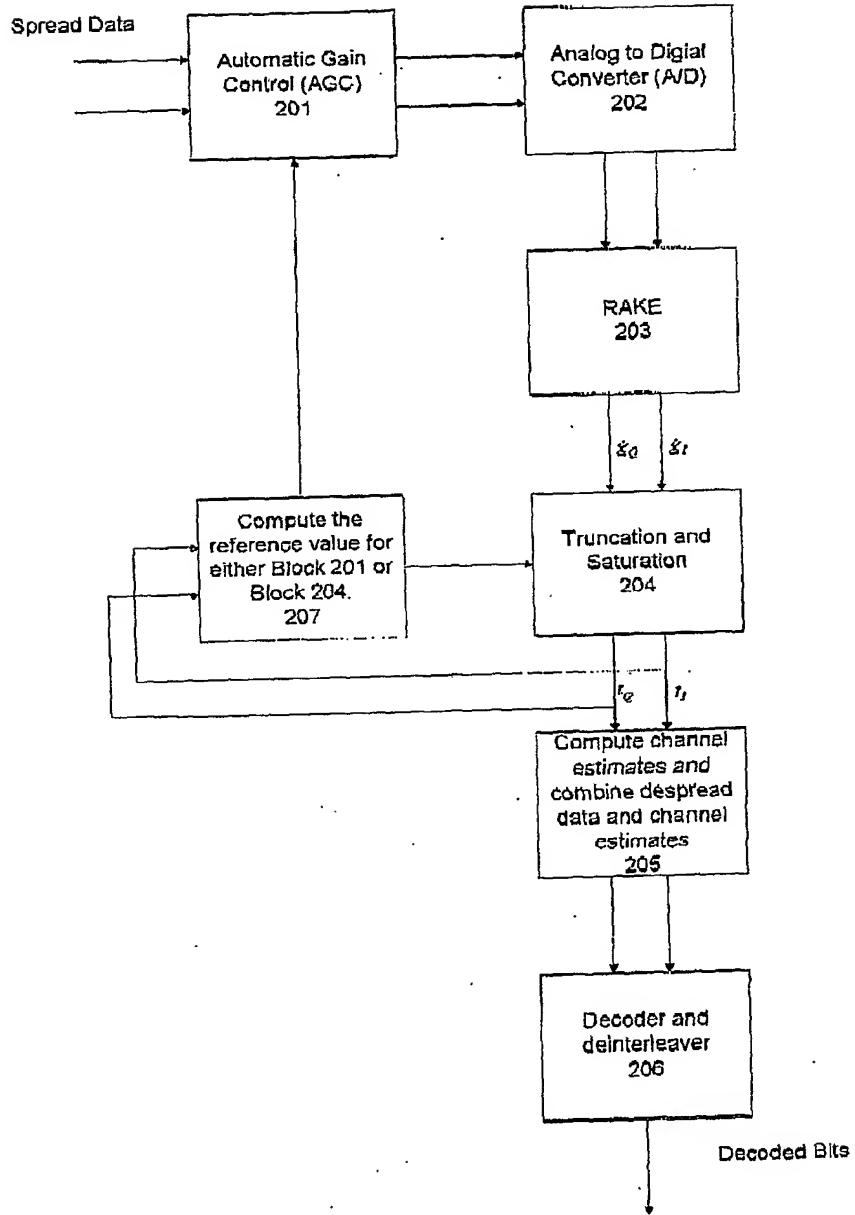


Fig. 4

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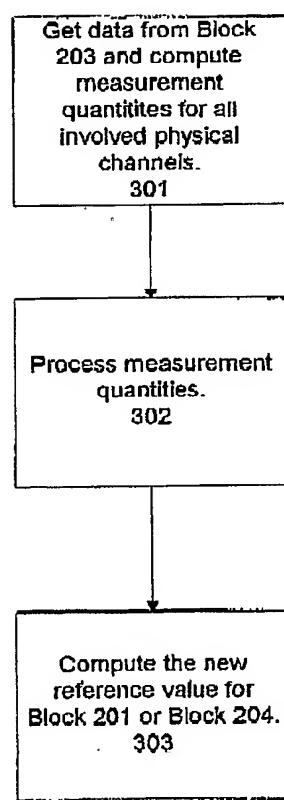


Fig. 5